I ought perhaps to add one further observation about the litigation of such claims. In a recent case the claim was brought against the surgeon and the sister who had been responsible for the counting of the swabs. I suppose that this was done on the basis that the combined duties of the two of them together covered the whole field of activity, within which any negligence connected with the non-extraction of the swab must have occurred. A similar joinder of defendants would be likely to be made in any similar case. If more than two persons may be involved in the negligence, more than two may be brought in as defendants. This is, after all, a natural procedure, if it is certain or almost certain that,

assuming negligence to have occurred, one or more of (say) three persons are guilty of the negligence, but it is still uncertain to which the blame is to be attributed, and only the investigation of the facts at the trial will settle the matter. The plaintiff will have good reason for being cautious about joining as defendants persons against whom he is not likely to succeed, inasmuch as he may have to pay their costs. The questions of the assessment of the damages which a successful plaintiff is entitled to recover, and of the apportionment of damages if the plaintiff succeeds against more than one defendant, do not fall within the scope of this article.

INTUSSUSCEPTION IN CHILDREN

Its Diagnosis and Treatment

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The treatment of intussusception in children by conservative measures (enemata or manipulation) is very old. During the earlier years of this century, as the safety of operative treatment increased, it was almost abandoned. Here and there, however, it still had advocates. The great advantage of conservative treatment is obvious; laparotomy is avoided. It is, however, a blind measure and its greatest danger was the fact that its success or failure was never immediately known. In a large number of cases it was not discovered that the reduction had been incomplete until hours or days had passed. Precious time was thus wasted, the risks of laparotomy had increased and a high mortality resulted.

To-day the non-operative treatment of intussusception in children in its modern form with the barium enema under fluoroscopic control is almost without danger, provided always that it is administered by an experienced radiologist. With X-rays the diagnosis can be confirmed at once, the typical diagnosis can often be exact, and one can with certainty know when reduction is complete. It is, however, essential that the radiologist in

charge shall be a man of skill and experience in interpreting the radiological findings.

The History of the Barium Enema Method

The barium reduction method has especially gained ground in those countries where the simple enema and manipulation methods had never been given up, and where their considerable advantages were appreciated. The fact that the barium enema method has not been accepted in Anglo-Saxon countries is no doubt due to the fact that the old methods had there been quite abandoned before the barium method was introduced in 1927. Certain series of good results of operative treatment from surgical departments of children's hospitals certainly contributed to this, as probably also did unwise and unskilled adherents of the older conservative school.

In the writings of last century the use of a column of water 4 to 6 m. (13 to 20 ft.) is recommended, to be applied by 'laying the child in the hallway and raising the funnel by mounting the stairs.' Mortimer tried to find out how great a pressure the normal colon can withstand

FIGS. 1 and 2.—Colic intussusception in boy eight years old. The gas-distended colon ends funnel-shaped in the neck of the intussusception at the left iliac crest. After the injection (Fig. 2) a typical intussusception figure is seen, with inflow of enema about the intussusceptum. The extent of the invagination can be estimated from the picture.

without rupture. He made post-mortem room experiments and found that the force should be much less than had generally been supposed to be safe. The writer has performed similar examinations which showed that, based on modern conceptions, the large bowel of a normal child can stand a very high pressure.

In France the enema methods seemed quite abandoned, but the barium enema method had a strong advocate in Pouliquen. French surgeons were interested in the method as a means of diminishing the intussusception (partial reduction) before operation. After much controversy it was adopted also as a means of complete reduction, but in spite of the 'consecration officielle' of Ombredanne, it has by no means achieved general acceptance.

In Scandinavia things were otherwise. Here the old conservative methods had never quite been driven from the field. In Denmark, at the Queen Louise Children's Hospital, for more than 50 years the non-operative methods of treatment in the form of water injections (Hirschsprung, Wichmann) or taxis (Monrad) had been advocated.

There generations of young doctors have been taught to make the diagnosis early in the disease. They have been made aware of the disease, have learnt to listen to the mother's story and know the four cardinal points of *colic, vomiting, blood in the stools and an abdominal mass*, combined with the typical pallor. Moreover, articles throwing light on the subject from all angles are constantly appearing in Denmark, so that the problem is kept before their minds. These features are of the greatest importance, because the success of every type of conservative treatment depends on *early diagnosis* and the earliest possible institution of treatment, a fact not at all upset by the results of exceptionally skilled radiologists such as Hellmer (1948), who have obtained complete reduction even in the later stages of the disease.

Before passing on to the subject of diagnosis and therapy by the barium enema method, the writer would like to stress the importance of:—

- (a) Educational campaigns aiming at earlier reference of patients for diagnosis and treatment;
- (b) Provision of facilities for immediate ex-

FIG. 3.—Typical ileocaecal intussusception (ascending colon, detail).

amination and treatment by experienced radiologists; and

(c) A friendly attitude towards the non-operative treatment of intussusception on the part of all those concerned.

The writer hastens to add that cases of intussusception should by all means remain under the care of the surgeons, on the surgical side, but should be referred to the radiologist for attempted reduction with the barium enema. In Denmark this is the normal practice, the surgeon often coming to the radiological department to be present during the procedure.

Radiological Diagnosis

1. *Straight films* in recumbent position before injection of barium suspension should never be omitted, as it is possible from them to form an estimate of the gas-distension of the bowel and to gain information not only about the presence of an ileus, but also about the type of the intussuscep-

FIG. 5.—Ring-formed intussusception figure in the right flexure, where the intussusception is seen in cross-section.

tion (Fig. 1). It is helpful in diagnosing whether large or small bowel is involved, thus giving some guidance as to the manner in which the enema is to be given.

In X-rays taken with the patient standing, sitting or suspended, fluid levels with dome-shaped gas accumulations above may be present.

2. A *diagnostic barium enema* is then given, provided that it is not contraindicated by a possibility of appendicitis.

The *intussusception figure* is the picture that appears when the apex of the intussusceptum is surrounded by barium. Commonly it takes the form of a cup or crescent-shaped rarefaction in the barium shadow, usually with a sharply outlined margin (Fig. 3), often like a 'fork-figure' or 'earwig-pincers' (Fig. 4). If the barium has advanced for some distance about the intussusceptum a negative picture of the latter may be obtained in the form of a filling-defect enclosed by two horn-like projections or arms. If the intussusception is seen in cross-section the figure may become

Courtesy: Jacob Nordentoft, Surgeon-in-chief

FIG. 4.—Typical fork-figure resembling earwig pincers in a boy aged five months. Note tip of metal obturator in the anus.

ovoid or annular (Fig. 5), and if the intussusceptum consists of small bowel, broad lines of barium shadow may demonstrate that the intussusception is one that has passed into the colon through the ileocaecal junction (Edberg's sign of ileocolic intussusception; Figs. 6 and 9). Another frequent picture is a series of rings, due to a concertina-like contraction of the intussusciptens about the invaginated portion. This is especially seen during the evacuation of the enema, where an intussusceptum that has been very much reduced by the fluid pressure draws the sheath with it when it again moves forward (Figs. 7 and 10).

Demonstration with a barium enema of a figure resembling an intussusception is not, however, conclusive proof of the diagnosis. Only in a child with symptoms of obstruction, where the figure is movable, and where it disappears only when it has been reduced to the ileocaecal region does the diagnosis become certain. It is therefore justifiable to speak of the intussusception figure as *the fifth cardinal sign of intussusception in children*.

3. *Topical diagnosis* (see diagrams, Figs. 8 and 12).

Pure colonic intussusception may be diagnosed from the straight film (Fig. 1). With the barium enema the distance from the funnel-shaped termination of the gas figure to the cup-shaped caput outlined by the fluid may indicate the length of the intussusceptum (Fig. 2).

Pure ileal intussusception can be recognized when the enema flows into the small bowel, here producing the typical figure near the ileocaecal junction (Figs. 8a and 11). Figs. 9 to 11 demonstrate three stages in the reduction of an ileocolic intussusception, the last figure showing the remaining pure ileal intussusception from which the complicated invagination has started (compare Fig. 8, where c, b and a correspond to Figs. 9, 10 and 11 respectively).

Enterocolic intussusceptions form up to 80 per cent. of the total. They are subdivided into ileocaecal, and the various ileocolic types. In the former the apex is formed either by the caput caeci or by the ileocaecal valve (Fig. 12). Edberg's

FIG. 6.—Ileocolic intussusception 12 hours old in girl aged nine months. The plain film had showed small fluid levels. There is *positive Edberg's sign*: caecum and appendix filled, but the intussusceptum is distinctly seen in the ascending colon. At operation no invagination was found. The appendix lay free; there was some oedema of the caecum, especially the valve; 10-12 cm. of the adjoining ileum were dark red with subserous haemorrhages.

FIG. 7.—Post-evacuation picture of compound ileocolic intussusception in a girl aged 16 months. Considerable gas in the small bowel. Numerous annular figures surround the intussusceptum, which distends the ascending colon. (Detail.)

FIG. 8.—Diagrams to show the development of an ileocolic intussusception; (3), (2) and (1) correspond to the figures 9, 10 and 11 respectively.

FIG. 9

FIG. 10

FIG. 11

FIGS. 9 to 11.—Three phases in the partial reduction of an ileo-ileocolic intussusception in a girl aged five months. (Details.) FIG. 9: Large intussusceptum in the caecum and ascending colon. Only ileocolic invagination can be diagnosed. FIG. 10: Partial reduction. The caecum is filled, but a small filling defect is still to be seen in the ascending colon. The enema has passed Bauhin's valve and surrounds the intussusceptum in the terminal ileum. FIG. 11: Caecum and ascending colon are well filled, but there remains a pure ileal intussusception. The patient was operated upon and did well.

sign, mentioned above, is pathognomonic of an ileocolic intussusception. Hellmer, in the majority of cases, succeeded in pushing such an intussusception back through the dilated orifice of the ileocaecal (Bauhin's) valve into the ileum, and he believes that ileocaecal intussusceptions in the true sense are exceptional.

The Therapeutic Barium Enema

It is evident from what has been said that diagnosis and therapy to a certain extent go hand in hand. The diagnostic injection must always be made under a low pressure and under constant fluoroscopic control, otherwise the diagnosis may be missed as loose invaginations can be reduced with a minimum pressure.

If an intussusception is found, the enema is continued by allowing the fluid to enter for some minutes under a pressure of 3 to 4 ft. In cases of less than 24 hours' duration the pressure may be increased to 4 ft. 6 in. or more, but it is never allowed to exceed 6 ft. The anus of the child should be occluded either by means of a metal or ebonite obturator (Fig. 4), or by using a thick rubber tube and pinching the buttocks together around it. Hellmer is right when he says: 'Attach the greatest importance to the nurse who assists *ad anum*. . . . This assistance is . . . quite as important for a successful result as the work of the roentgenologist. Place the untrained helper

at the instrument table and the trained nurse at the enema can.' Rouliquen has constructed a very useful rubber tube with a water-distensible balloon for occlusion of the anus.

When the reduction is almost complete, the caecum, particularly on its medial side in the region of the ileocaecal valve, is the key-point. *Complete filling of the caecum and satisfactory reflux into the ileum are the two important radiological signs of reduction.*

After the examination, the enema is evacuated and further X-rays are taken. These post-evacuation pictures are important because the condition can best be studied after the colon has collapsed. If reduction is not certain the injection is repeated under pressure and again the caecum and lower ileum are examined for filling (Figs. 13 and 14).

According to Hellmer it is possible, without anaesthesia, to obtain inflow into the small bowel in *all* cases in which the intussusception has been reduced. This is the result, probably, of repeated enemata. With one injection only reflux into the ileum is obtained in about 50 per cent. of cases.

If there is doubt about the reduction, a charcoal tablet dissolved in water may be given by mouth. If an enema given five hours later is returned with particles of charcoal, it proves fairly reliably that the obstruction has been relieved.

FIG. 12.—Diagram showing ileocaecal intussusceptions; in those to the left the apex is constituted by the ileocaecal junction, in those to the right by the fundus of the caecum.

If there is doubt about the reduction—which there will always be if the enema does not pass into the small bowel—intervention is indicated. In early cases a brief delay, not exceeding a few hours, may be allowed.

It is essential that the caecum be completely filled (Figs. 13 and 14). If it contains a filling defect (Figs. 15, 16 and 17), and particularly if there is no reflux into the ileum, operation is indicated. If the procedure here indicated is closely followed, it will rarely be necessary to operate merely for the purpose of exploration.

In almost all cases it will be possible to obtain at least a partial reduction of the intussusception by means of the barium enema. This is of advantage in planning the most suitable incision for the subsequent laparotomy.

Post-Examination Care

The after-care is extremely important. If colic or vomiting recur, further X-ray examination or operative intervention is indicated. In the writer's experience the child's condition is often improved even when reduction is incomplete. The fact that the child seems to be improved, begins to drink or falls asleep does not, in fact, necessarily mean that the intussusception has been reduced. *Clinical improvement is therefore a dangerous sign upon which to rely. The radiological signs of complete reduction are of paramount importance.*

Elements of Danger

The principal criticism of the barium enema method is the risk of thinking that reduction is complete when it is, in fact, incomplete. It is here shown that proof of reduction can be obtained in a high percentage of cases.

As regards organic changes these are of less importance, at least in small children. In this book Hellmer shows how useful the barium enema can be in the diagnosis of polypi, of Meckel's diverticulum, etc. The risk of rupture of the bowel has been mentioned, but by careful technique this disaster should not occur. The writer has not seen it in his series of 200 cases. A diagnosis of appendicitis has been mentioned as a contra-indication to a barium enema.

The objection that precious time is wasted can hardly be taken seriously—the barium enema can be given while the surgeon washes his hands! In the writer's experience the whole X-ray procedure has seldom lasted more than one hour. The children are not exhausted, probably because of the resorption of water, and possibly on account of the removal of toxic products; for the same reason, in fact, which makes it unwise to rely on clinical improvement which may be seen where reduction is still incomplete.

FIG. 13.—Intussusception three hours old, in boy aged three years, reduced by high barium enema pressure. The last loop of the ileum points almost vertically downwards, toward the medially directed ileocaecal junction. Caecum well filled, good inflow into the small intestine.

Results of the Treatment

In comparison with the results which can be obtained by primary surgical treatment, the results of the barium enema treatment are able to compete. In the years 1934-1939 Monrad (Copenhagen) treated 39 cases with the barium enema method; none died; seven had to be operated upon secondarily.

In 1943 Hellmer published a series of 110 cases, 80 per cent. of which were reduced by barium enema without operation (no deaths); 22 had to be operated upon secondarily, of these eight died. In his book, published shortly before his death, his material had risen to 162 cases, of which 130 were reduced by barium enema without a death. Of 30 cases in which reduction with the barium enema was unsuccessful and laparotomy was subsequently performed, nine died. This corresponds to a 5.6 per cent. mortality for the whole series. None of his cases from the university clinic of Lund were operated upon primarily.

Further information about these cases and the writer's own material appears in Table 1.

FIG. 14.—Ileocaecal intussusception seven hours old in a girl aged nine months; *reduced with barium enema*. The caecum well filled. Good inflow into the small bowel.

Concluding Remarks

In Denmark the barium enema method has been almost universally adopted. During the years 1928 to 1935 the use of the opaque enema rose from 10 to 90 per cent. of all intussusception cases in children (statistics from all Danish surgical departments and the Queen Louise Children's Hospital).

The experience of the writer seems to an increasing degree to show that in all early cases (within the first 24 hours of the disease) an energetic attempt at reduction should be made, all clinical and roentgenologic diagnostic criteria and the condition of the child being taken into consideration. In this respect the writer agrees

with Wichmann, who in 1893 said of the conservative treatment of intussusception:—

'The time is simply wasted if these attempts at reduction are not carried out energetically; for it will then be a mere matter of chance whether the reduction is effected or not, and the result will often be that attempts are abandoned which might have succeeded if they had been better conducted.'

The either-or of earlier years in Denmark has disappeared. We now use the method routinely. This is due to the fact that diagnostic accuracy has increased very much both with regard to making the diagnosis, and with regard to verifying the reduction.

Courtesy: Jacob Nordentoft, Surgeon-in-chief

FIG. 15.—*Non-reduction*: incomplete filling of the medial side of the caecum. (Detail.) Boy aged six months.

FIG. 16.—*Non-reduction*: ileocolic intussusception four days old in boy aged four years. The rarefaction in the caecum was supposed to be due to faeces or tumour. The following day there was a copious discharge from the bowel, but six days later operation had to be performed and an ileocolic intussusception and a Meckel's diverticulum were found. The patient died the same day.

FIG. 17.—Invagination of a haustrum caeci in a boy aged three years—verified by operation the following day. Roundish regular indentation on the lateral side of the large intestine. (Detail.)

TABLE I
CONSERVATIVE TREATMENT OF INTUSSUSCEPTION IN CHILDREN

	Total Num- ber	Reduced Con- servatively	Not Reduced	Point of Origin			Comment
				Ileum	Colon	Uncer- tain	
Hellmer (Sweden, 1943)	110	88 (80%)	22	51	7	52	1933-42. Personal material. In all cases barium reduction attempted. Eight deaths (all operated upon).
Nordentoft (Denmark, 1943)	440	134 ¹ (31%)	299 ²	128	312		All surgical departments and Queen Louise Hospital, 1928-35. Many of the enemas given for diagnostic purposes. Seven patients not treated. 16 cases certainly purely colonic.
Monrad (Denmark, 1944)	207	151 ³ (73%)	56 ⁴	?	?	?	1906-39. Personal material; Queen Louise Hospital for Children, Copenhagen.

¹ 97 barium examinations only, two deaths; 37 conservatively only (without X-ray diagnosis), three deaths.
² 100 operations after barium examination, 23 deaths; 14 after conservative treatment (without X-ray examination), six deaths; 185 primary operation, 41 deaths.
³ 32 barium examination only (1934-39), no deaths; 119 taxis only, 13 deaths.
⁴ Seven operations after barium examination, no deaths; 24 after taxis, 15 deaths.

To sum up, therefore, intussusception still comes under the care of the surgeons but they refer the cases primarily for reduction by the opaque enema method. Only if this fails or reduction is uncertain is operation necessary.

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